A Comparison of Moth Diversity at Kilauea (1911–1912) and Upper Waiakea Forest Reserve (1998–2000), Island of Hawaii

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Abstract. A group of entomologists inventoried and recorded moths at Kilauea on the Island of Hawaii almost a century ago. I conducted similar surveys 86 years later in the nearby Upper Waiakea Forest Reserve (UWFR). Results of these surveys provide a rare opportunity to compare and contrast changes in Lepidoptera relative abundance and species diversity over long periods of time. The Kilauea and UWFR survey sites share a similar climatic regime, forest community, and elevation, but are 15 km apart. Ninety-three species of endemic moths were recorded at Kilauea during the 1911–1912 survey: more than 94 species were collected at UWFR from 1998–2000. I compared the number and species of moths collected at both locations, except for those in the genera *Hyposmocoma* and *Eudonia*. At least 20 Kilauea species were not found at UWFR., more than 42 UWFR species were absent from the Kilauea site. The UWFR survey also produced a number of new island records and several species new to science. Many moth species that were rare in 1911–12 were rare in 1998–2000, but most were still collected. The number of non-native moth species doubled since the 1911–1912 survey. UWFR survey results indicate that the native moth fauna on windward Mauna Loa is still relatively intact and that many new species await discovery.

Key words: Hawaiian Lepidoptera, Kilauea, Upper Waiakea Forest Reserve, Stainback, moth surveys.

Introduction

Hawaii Island forests were favorite collecting areas for early entomologists like R.C. L. Perkins, W. M. Giffard, and O. H. Swezey. In fact, many moth species were described from specimens collected at Kilauea (also called "29 miles"). The latter name referred to the distance from Hilo to Kilauea, Hawaii along the old Volcano Highway. Some species collected at Kilauea have not been seen since the late 1800s. Lists of moths collected during these early years were often published in the Proceedings of the Hawaiian Entomological Society and provide valuable baseline information. It is generally recognized that native Hawaiian moth abundance and species diversity have been declining for decades (Gagne 1982). Suggested reasons are the introduction of non-native larval predators (parasitic wasps, yellow jacket wasps, and ants) and habitat loss through invasion of non-native plants, forest clearing, and urban development (Gagne and Howarth 1982).

One notable moth survey was conducted at Kilauea in 1911 and 1912 by W. M. Giffard, E.M. Ehrhorn, D.T. Fullaway, and J.F. Rock. Moths collected by this group were identified and a list of species tabulated by Swezey (1913a). This information provides a good profile of Hawaiian moth diversity at Kilauea as it existed in the early 1900s and enables us to compare relative abundance and species diversity almost a century later. In 1998, I initiated a moth survey to document the relative abundance, species diversity, and distribution of

Lepidoptera near the southern boundary of the Upper Waiakea Forest Reserve (UWFR), hereafter referred to as Stainback. This particular area was selected because of its exceptional botanical diversity and pristine forest condition. I expected a rich diversity of moths because of the high quality habitat. At the conclusion of the survey, I compared the Kilauea and Stainback moth faunas to determine species composition similarity between the two sample periods. The Kilauea data set was chosen for this comparison because it was the oldest and most detailed account of a moth survey in similar habitat on Hawaii Island.

Study Areas

The Kilauea and Stainback sites are similar in many respects. Both are situated at approximately the same elevation and receive more than 2,500 mm of rainfall annually. Botanical composition is also comparable. The sites lie within a continuous belt of montane wet forest that extends across the windward flanks of Kilauea and Mauna Loa volcanoes. The plant community is classified as an ohia/hapuu *Metrosideros*/*Cibotium*) tree fern forest (Wagner et al. 1999) and is characterized by large ohia trees and a closed canopy tree fern layer. Understory vegetation consists of shade-tolerant trees, shrubs, ferns, and epiphytic plants. An occasional loulu palm (*Pritchardia*) emerges above the forest canopy. Kilauea and Stainback are approximately 15.0 km apart as the moth flies.

Kilauea. The Kilauea collecting site is located on the northern side of Kilauea volcano, near Volcano village. Its exact location is not known, but Swezey (1913a) reported that moths were collected "at Mr. Giffard's bungalow at twenty-nine miles, Kilauea, Hawaii." Giffard (1918) further placed the site "about two miles north of the Volcano House." and Swezey (1913b) gave the elevation as "4,000 feet." Road distances between Hilo and Kilauea were eventually altered when the old Volcano Highway was realigned and highway mile markers were changed. However, descriptions indicate that the study site was within or adjacent to the privately-owned Kilauea forest. A description of Kilauea forest vegetation as it existed in the early 1900s was recorded by Perkins (1906) and Rock (1913). Plant communities at this location developed on tephra deposits from Kilauea volcano and substrates have been radiocarbon dated at 1,500–3,000 years bp (Wolfe and Morris, 1996).

Stainback. The Stainback collecting site is located on the eastern side of Mauna Loa volcano, along the northern side of Stainback Highway. It is within the 22,456 ha UWFR which is owned by the State of Hawaii. Eight different sites along a power line right-of-way were selected for sampling moths (poles 108, 115, 123, 127, 135, 141, 154, and 166). Elevation of these sites varied from 975 to 1,311 m. The Stainback section of UWFR was exceptional in that it was essentially free of invasive non-native ants, yellow jacket wasps, and weeds. The area also supported an exceptionally diverse community of native plants including the following rare species: loulu palms (*Pritchardia beccariana*), *Cyrtandra giffardii*, aku (*Cyanea tritomantha*), *Cyanea platyphylla*, ohe (*Joinvillea ascendens*), *Phyllostegia floribunda*, *Phyllostegia vestita* and *Zanthoxylum kauaense*. This plant community developed on a relatively young (200–750 years bp) aa lava flow (Wolfe and Morris 1996). The lava appears to have been enhanced by deposits of wind-blown ash originating from a nearby scoria cone. An older kipuka on pahoehoe substrates (5,000–10,000 years bp) lies just north of the site, contributing additional plant diversity to the area (Fig. 1).

Stainback's lower boundary abuts the 4,856 ha Waiakea Timber Management Area. In 1959, this area was greatly modified when the State of Hawaii began clearing native forest and planting commercial timber species. Clearing and planting continued through 1968 after which time active management ceased. Invasive weeds are now widespread in the tree plantation and threaten the integrity of adjacent native forest.

Materials and Methods

Kilauea (1911–1912). Giffard's group collected and recorded moths at lights on the lanai of his bungalow from August, 1911 to August, 1912. "Moths were collected at various times...whenever Mr. Giffard and one or another of the above mentioned gentlemen visited the place for a few days or weeks during the past twelve months" (Swezey 1913a). Collecting was restricted to seven months: August, September, and December in 1911 and February, May, July, and August in 1912 (Swezey 1913a). They did not note how many evenings were spent collecting each month, but probably several nights since visits sometimes lasted for weeks. Moths were "collected at lights," but no information is available on the type of lights used. They were probably gas lanterns or incandescent bulbs.

Some of the taxonomic names listed by Swezey (1913a) have been synonymized or changed by later specialists. These names have been updated in this paper to reflect recent revisions as presented by Nishida (2002). A few additional species were collected at Kilauea by Giffard after the survey (in 1925) (Swezey 1926), but these are not considered here.

Stainback (1998–2000). I sampled moths at least once a month (19 evenings) from December, 1998 to September, 2000, except no collections were made in October, November, and December, 1999 and January, February, April, and June of 2000. Trapping was scheduled during the week before a new moon and traps were operated from dusk until approximately 10:30 pm, depending on the weather. I used a sheet light trap, illuminated by a generator-powered mercury vapor bulb to attract moths. This was supplemented by a Universal black light trap (BioQuip) on five occasions. Moths that were drawn to the sheet were identified and the number of individuals recorded by species. All uncommon moths or those that could not be identified in the field were collected and preserved for later study. Species determinations were made by reference to original descriptions, keys published by Zimmerman (1958a, 1958b, 1978), and direct comparison to specimens in collections at Bishop Museum and the Hawaii Department of Agriculture. I calculated a coefficient of similarity for the two faunas using the abundance-based Chao-Jaccard estimator as presented by Colwell (2005) in his EstimateS application. This non-parametric statistical estimator is better suited than classic indices for assessing compositional similarity between samples that differ in size, are known or suspected to be under sampled, or are likely to contain numerous rare species (Chao et al. 2004).

Results

A total of 93 species of native moth in 10 families was identified at Kilauea by Giffard et al. in 1911–12. This figure does not include four synonymized species: *Pseudaletia macrosaris* (Meyrick) = *Cirphis macrosaris, C. typhlodes*, C. *pyrrhias* and *Scotorythra oxypractis* Meyrick = *S. ortharcha*. I found more than 94 species in 10 families at Stainback during the 1998–2000 period (Table 1). Moth faunas at Kilauea and Stainback were composed primarily of endemic species, 89 and 82 percent, respectively. Some small moths in the genera *Hyposmocoma* (Cosmopterygidae) and *Eudonia* (Crambidae) were not routinely collected at Stainback so data for these groups are incomplete. The Kilauea moth fauna was dominated by species in three families: Crambidae (39 species, 42%); Geometridae (15 species, 16%); and Noctuidae (11 species, 12%). Slightly different proportions were documented at Stainback: Crambidae (26 species, 27 %); Noctuidae (25 species, 26%); and Geometridae (18 species, 19%). Presumably, Crambidae percentages would have been more similar if all *Eudonia* species had been adequately sampled at Stainback. The combined number of endemic species at Kilauea and Stainback was 111. For consistency, I did not include *Hyposmocoma* and *Eudonia* in that figure. Forty-four species were shared by both sites. The computed coefficient of similarity for the two samples was 0.734. This figure

indicates that species similarity was high between the two sample periods.

Two new island records and seven species new to science were found at Stainback during the survey (Table 1.). New records for the Island of Hawaii were *Macraesthetica rubiginis* (Walsingham) and *Mantua fulvosericea* (Walsingham). Both of these tortricids are considered endemic, however, there is some question about the residency status of *M. rubiginis*. New endemic species included moths in the following genera: *Udea, Progonostola, Scotorythra*, *Agrotis,* and *Haliophyle*. The two sites produced a number of *Udea* species, 10 at Stainback and 12 at Kilauea. Some of these moths are rarely collected on the Island of Hawaii. Other rare species found at Stainback included *Lophoplusia giffardi* (Swezey), *Pseudaletia macrosaris* (Meyrick), *Psudoschrankia epichalca* (Meyrick), *Scotorythra oxypractis* Meyrick, *Omiodes pritchardi* Swezey, *Haliophyle ignita* Warren, *Hypocala velans* Walker, *Lophoplusia pterylota* (Meyrick), *Peridroma neurogramma* (Meyrick), and an undescribed loulu fruit moth (*Carposina* sp.). Only the first three species were reported at Kilauea. The endemic inchworm genus *Scotorythra* contains 20 described species on the Island of Hawaii. Twelve of these species were collected at Stainback making this area exceptionally rich for large geometrids. Only seven species of *Scotorythra* were recorded at Kilauea in 1911–12.

Bishop Museum staff conducted invertebrate surveys in the Stainback area at the proposed correctional facility site (884–975 m elev.) during the weeks before the new moon in October, November and December, 1998 and in early January, 1999. They recorded three native and eight non-native species of moths that were not encountered at my sampling sites (Howarth et al., 1999). These species are included in Tables 1 and 2.

Discussion

Identification concerns. *Macraesthetica rubiginis* was not known to occur on the Island of Hawaii until I collected two specimens at Stainback in 2000. Because this species can look exactly like *Bradleyella semicinereana*, I became suspicious that the later is not a valid species, but rather a synonym of *M. rubiginis*. Forewing color and markings of *M. rubiginis* are somewhat variable, but four of the nine specimens I have collected to date match that of the holotype figured in Zimmerman (1978: 511, fig. 314 top). Additionally, *M. rubiginis* males exhibit an unusually thick antenna, identical to that of *B. semicinereana*. This feature is not typical of other *Bradleyella* males. *B. semicinereana* is known only from a single specimen collected at Kilauea in 1912. Swezey (1913b) described this species and placed it in the genus *Tortrix*. Zimmerman (1978) subsequently combined *Tortrix* and *Eulia* under the name *Bradleyella*. The male character that he used to separate *Bradleyella* from all other genera in Hawaii was the presence of unusual abdominal spines. It is not known what character Swezey used for the generic placement of the Kilauea moth since the abdomen of the holotype male was missing. *B. semicinereana* was never collected again according to Zimmerman (1978). It is my opinion that Swezey's determination was in error and that the species he described was actually *Macraesthetica rubiginis*. I reached this conclusion because *M rubiginis* was not known to occur on Hawaii Island in 1913 and Swezey's specimen did not have an abdomen to confirm the presence of apical spines, a key *Bradleyella* character. I have not examined the only known specimen of *B. semicinereana*, but base my belief on circumstantial evidence.

Apparent trend. The decline of endemic moth species in high quality habitat on windward Mauna Loa appears to be minimal since 1912, especially in light of widespread ecosystem disturbances. I was able to find 45 of the 67 endemic Kilauea moth species at Stainback during the survey period. I collected another 13 Kilauea species at various locations on Mauna Loa volcano after the Stainback survey ended. An additional species, *Eupithecia dryinombra*, is still extant according to Stephen Montgomery (pers. comm.).

This leaves eight species or 12 percent that could not be located. Two Kilauea moths, *Agrotis crinigera* (Butler) and *Omiodes fullawayi* Swezey, were presumed extinct (Gagne and Howarth 1982) and, therefore, not expected at Stainback. *Fletcherana giffardi* (Swezey) is probably a Kilauea endemic or possibly extinct. The five remaining species may have been overlooked or missed due to inadequate sampling. They are *Carposina herbarum* (Walsingham), *Megalotica aphoritis* (Meyrick), *Udea platyleuca* (Meyrick), *Scotorythra capnopa* Meyrick, and *Pseudaletia amblycasis* (Meyrick). An unexpected result was the great number of unique species at Stainback. At least 42 species identified there were absent from the Kilauea site. This greater species richness at Stainback may be due to the increased effectiveness of mercury vapor lights as compared to the lights used by Giffard at Kilauea. The larger geographic coverage at Stainback and wider elevational range may have also increased species numbers. Additionally, I compared species collected over a 13 month period at Kilauea with those taken over 22 months at Stainback.

Many species that were rare in 1911–1912 continued to be rare during my surveys. Examples are *Lophoplusia giffardi*, *Merimnetria gigantea* (Swezey), *Pseudaletia macrosaris*, *Psudoschrankia epichalca*, and some *Udea* species. It is possible that these moths are not actually rare but are seldom attracted to lights. A few common species such as the native sphinx moth (*Hyles wilsoni wilsoni* (Rothschild) and a geometrid (*Scotorythra artemidora* Meyrick) were not reported at Kilauea, but are very common at Stainback and other forested areas on the Island of Hawaii. Survey results indicate that Hawaii Island moths are inadequately known and that many new species await discovery.

Native moths in the genera *Hyposmocoma* and *Eudonia* were not routinely collected at Stainback. Unfortunately, this introduces a gap in the data set and diminishes its value for comparing the two samples. The computed coefficient of similarity may have been different and species richness comparisons would be more meaningful if these two groups had been recorded at Stainback.

Non-native species. Invasions of non-native moths are generally thought to be correlated with native forest disturbance and invasive weeds that serve as host plants for these insects. The proximity of agricultural crops or urban areas also influences the distribution of invasive insects. Only 11 non-native moth species in six families were recorded at Kilauea while 21 species in seven families were observed at Stainback (Table 2). The higher number at Stainback partially reflects new moth introductions since the Kilauea survey, but also possibly the influence of forest disturbance at Waiakea Timber Management Area and increased urbanization nearby.

Conservation perspective. Only general information is available regarding the condition of Kilauea forest in 1911 and 1912. Rock (1913) noted that "Immediately back of the Volcano House is the fern or rain forest, composed of the tree ferns *Cibotium Menziesii* and *Cibotium Chamissoi*, which reach here a wonderful development as far as fronds are concerned…" However, he goes on to say "…the native undergrowth is now being driven out by the tenacious *Rubus jamaicensis*, or thimble berry, an introduced pest…" and "Besides this obnoxious plant, another one has been introduced of late, the ordinary blackberry, which already shows signs of having taken a strong foothold." It is evident that invasive weeds were already having an impact on Kilauea forest in 1911–12, but given the reported moth diversity, it can be assumed that the area still provided high quality habitat for arthropods. Kilauea Forest is currently owned by Kamehameha Schools and is being managed for protection of native resources. Much of the area has been fenced and feral ungulates are being removed (Kamakane Dancil, pers. comm.).

Forest condition, botanical diversity, and moth species richness at Stainback are exceptional when compared to other State-owned forest reserves on the Island of Hawaii. This site receives some protection and management under existing forest reserve rules

(Chapt.104), but large numbers of feral pigs and invasive weeds such as palm grass (*Setaria palmifolia*) threaten forest integrity. Proposed logging activities in the adjacent Waiakea Timber Management area could further fragment the forest and accelerate the spread of pest invertebrates and weeds. If approximately 405 ha of forest at Stainback were set aside by the State as a Natural Area Reserve and managed for long-term biodiversity protection, this might preserve a significant measure of endemic moth diversity. Critical first steps would be fencing, removal of feral pigs, and controlling palm grass.

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Literature Cited

Chao, A., R.L. Chazdon, R.K. Colwell, and **T-J. Shen.** 2004. A New Statistical Approach for Assessing Similarity of Species Composition with Incidence and Abundance Data. Ecology Letters 8:148–159.

Colwell, R.K. 2005. EstimatesS: Statistical Estimation of Species Richness and Shared Species from Samples. Version 7.5 User's Guide and Application Published at http://purl.oclc.org/estimates.

Gagne, W.C. 1982. Working Toward an Assessment of the Conservation Status of Hawaii's Endemic Arthropods**,** with Emphasis on the Moths or Lepidoptera. Proceedings of the 4th Conference on Natural Sciences, Hawaii Volcanoes National Park Science Conference. Pp. 63–72. University of Hawaii, Honolulu.

Gagne, W.C. and **F. G. Howarth.** 1982. Conservation Status of Endemic Hawaiian Lepidoptera. Proc. 3rd. Congr. Eur. Lepid., Cambridge. pp 74–84.

Giffard, W.M. 1918. Notes on Delphacids Collected on a Short Visit to Portions of the Intermediate Forests in Olaa and in North and South Kona, Island of Hawaii. Proc. Hawaiian Entomol. Soc., III, No. 5: 407–412.

Howarth, F.G.; R.H. Cowie; D.J. Preston, R.J. Rundell; R.A. Englund; F.D. Stone, and **S.L. Montgomery.** 1999. Proposed new Hawai'i Island Correctional Facility, Waiakea, South Hilo, Island of Hawaii: Assessment of Potential Impacts on Invertebrates (Snails, Insects and Other Arthropods) of Proposed Improvements to Stainback Highway. Final Report submitted to Wilson Okamoto & Associates, Inc., Honolulu, Hawaii. 90 pp.

Nishida, G.M. (ed.) 2002. Hawaiian Terrestrial Arthropod Checklist. Fourth Edition. Bishop Museum Technical Report No. 22: iv + 313 p.

Perkins, R.C.L. 1906. Insects at Kilauea, Hawaii. Proc. Hawaiian Entomol. Soc. 1: 89–99.

Rock, J.F. [1913] 1974. The Indigenous Trees of the Hawaiian Islands. Reprint, with introduction by S. Carlquist and addenda by D.R. Herbst. Privately Pub. (pp. 27–33).

Swezey, O.H. 1913a. Kilauea Moths. Proc. Hawaiian Entomol. Soc., II, No. 5: 233–237.

Swezey, O.H. 1913b. One New Genus and Eighteen New Species of Hawaiian Moths. Proc. Hawaiian Entomol. Soc., II, No. 5: 269–280.

Swezey, O.H. 1926. Kilauea Moths. Hawaii. Proc. Hawaiian Entomol. Soc. VI, No. 2: 291–292.

Wagner, W.L., D.R. Herbst and **S.H. Sohmer.** 1999. Manual of the Flowering Plants of Hawaii.

Revised edition, Vol. 1. Univ. Of Hawaii Press. Bishop Museum Press. 988pp.
Wolfe, E.W. and **J. Morris.** 1966. Geologic Map of the Island of Hawaii. U.S. Dept. of the Interior. Misc. Investigations Series. Map I-2524-A (Sheet 2 of 3). U. S. Geological Survey.
Zimmerman, E.C. 1958a. Insects of Hawaii. Vol. 7, Macrolepidoptera. Univ. of Hawaii Press. Honolulu. 542 pp.
Zimmerman, E.C. 1958b. Insects of Hawaii. Vol. 8, Lepidoptera: Pyraloidea. Univ. of Hawaii Press. Honolulu. 456 pp.
Zimmerman, E.C. 1978. Insects of Hawaii. Volume 9, Microlepidoptera, Parts I & II. Univ. of Hawaii Press. Honolulu. 1,903 pp.

Table 1. Number of endemic moth species present at Kilauea (1911–12) and upper Waiakea (1998–2000). Taxonomic names used at Kilauea are listed in parentheses.

Taxon	No. of individuals counted 1911–1912	1998–2000
Carposinidae (Carposinid fruit moths)		
Carposina (*Heterocrossa*)		
gemmata	2	3+
gracillima	2	0[1]
herbarum	2	0
inscripta	2	3+
latifasciata	3	0[1]
olivaceonitens	0	5+
plumbeonitida	3	3+
tincta	0	3+
undesc. sp. #1 (loulu fruit moth)	0	3
Cosmopterygidae (Cosmopterygid moths)		
Hyposmocoma		.
Kilauea: 7 species; UWFR: 3+ species	none	none
Prays		
fulvocanellus	4	0[1]
Crambidae (Crambid moths)		
Eudonia (*Scoparia*)		
Kilauea: 19 species; UWFR: 3+ species	NA	NA
Mestolobes		
mesacma	6	3
minuscule	0	3+
ochrias	8	0[1]
droseropa ?	0	3
p*yropa*	0	1
Omiodes		
accepta	14	13+
anastreptoides	0	8
fullawayi	2	0
localis	3	3+
pritchardii	0	7
scotaea	24	8+
Orthomecyna		
epicausta	1	0[1]

exigua exigua	0	3+
metalycia	90	30+
Uresiphita		
polygonalis virescens	0	3+
Udea (*Phlyctaenia*)		
argoscelis	1	0[1]
**callistra synastra*	29	1
caminopis	2	2
chalcophanes	0	1
chloropis	5	0[1]
eucrena	31	7
liopis	1	0[1]
phaethontia	0	1
platyleuca	1	0
pyranthes	17	13+
metasema	30	7
micacea	3	5
stellata	4	1
thermantoides	4	4
new sp. #1	0	3
Gelechiidae (Gelechiid moths)		
Merimnetria		
gigantea (*Aristotelia gigantea*)	1	3
Geometridae (Inchworms)		
Eupithecia (*Eucymatoge*)		
craterias	11	5+
dryinombra	6	0[1]
monticolens	71	18+
orichloris	30	11+
staurophragma	0	9+
Fletcherana (*Hydriomena*)		
giffardi	2	0
roseate	9	11+
Megalotica (*Hydriomena*)		
a*phoritis*	8	0
Progonostola		
n. sp. #1	0	1
Scotorythra		
apicalis	0	5
arboricolans	1	16+
artemidora	0	14+
capnopa	6	0
corticea (*S. aruraea*)	23	0[1]
euryphae	78	12+
goniastis	0	9+
oxypractis (*ortharcha*)	36	7
pachyspila	11	3+
paludicola	130	1
rara	108	17+
n.sp. #13 (*willisi*)	0	6

n.sp. #5	0	5+
n. sp.#8 nr. *kuschei*	0	3+
Gracillariidae (Gracillariid leaf miners)		
Philodora		
basalis	1	0[1]
Noctuidae (Underwings, cutworms, and relatives)		
Agrotis		
ceramophaea (*Episilia ceramophaea*)	4	10+
charmocrita	0	6+
crinigera	5	0
diplosticta	0	4+
dislocata	0	3+
psammophaea	0	3+
xiphias	0	3+
n. sp. #1 (undescribed)	0	3+
n. sp. #2 (undescribed)	0	3
Haliophyle		
compsias (*Hyssia compsias*)	3	4+
euclidias (*Eriopygodes euclidias*)	139	50+
flavistigma	0	10+
ignita	0	9+
n.sp. # 1	0	3
Hypocala		
velans	0	1
Lophoplusia		
giffardi (*Plusia giffardi*)	6	2
pterylota	0	3
Peridroma		
albiorbis	0	1
cinctipennis (*Agrotis cinctipennis*)	3	0[1]
coniotis	0	2
neurograma	0	1
selenias (*Agrotis selenias*)	1	8+
Pseudaletia		
amblycasis (*Cirphis amblycasis*)	8	0
macrosaris (*Cirphis macrosaris, typhlodes*, *pyrrhias*)	3	1
undescribed sp. #1 (large red species)	0	11+
Schrankia		
altivolans (*Hypenodes altivolans*)	7	3+
simplex	0	3+
Psudoschrankia		
epichalca (*Hypenodes epichalca*)	4	2
Oecophoridae (Oecophorid moths)		
Thyrocopa		
albonubila	4	0
nubifer	0	2
fraudulentella	1	2
new species (undescribed)	0	2
Pyralidae (Pyralids)		
Homoeosoma		
**albosparsum* (*Homoeosoma amphibola*)	1	1

Sphingidae (Hawkmoths)		
Hyles		
wilsoni	0	10+
Tortricidae (Leaf rollers, leaf tiers)		
Bradleyella		
** *semicinereana* (*Tortrix semicinereana*)	1	0
Cydia		
walsinghami (*Enarmonia walsinghami*)	1	0[1]
*undet. sp. #1	0	1
Eccoptocera		
foetorivorans	1	1
Macraesthetica		
***rubiginis*	0	2
Mantua		
nr. *fulvosericea*	0	1
Panaphelix		
marmorata	2	4
Pararrhaptica (*Archips*)		
fuscocinerea	1	3
longiplicata	4	1
sublichenoides	7	1
subsenescens	4	8
Spheterista		
pleonectes (*Capua pleonectes*)	1	13+
TOTAL SPECIES	93	94+

[1] Species collected by the author at other sites on Mauna Loa volcano between 2000 and 2006.
* Species collected at the proposed correctional facility survey site in 1999 by Bishop Museum staff (Howarth et al., 1999). ** See Identification Concerns in Discussion section.

Table 2. Non-native moth species present at Kilauea (1911–12) and Upper Waiakea (1998–2000). Taxonomic names used at Kilauea are listed in parentheses.

Taxon	Kilauea 1911-1912	Stainback 1998-1999
Crambidae (Crambid moths)		
Herpetogramma		
licarsisalis		X
Nomophila		
noctuella	X	
Geometridae (inchworms)		
Macaria		
abydata		X
Noctuidae (Underwings, cutworms, and relatives)		
Agrotis		
ipsilon	X	X
****Ascalapha***		
odorata		X

Athetis		
thoracica		X
****Callopistria***		
maillardi		X
Chrysodeixis *(Plusia)*		
eriosoma (chalcites)	X	X
****Hypena***		
laceratalis		X
Hypocala		
deflorata		X
Lycophotia	X	
porphyrea		
Megalographa (*Plusia*)		
biloba	X	
Pseudaletia		
unipuncta	X	X
****Rhynchopalrus***		
brunellus		X
****Spodoptera***		
sp.		X
Spoladea		
recurvalis		X
Oecophoridae (Oecophorid moths)		
Endrosis		
sarcitrella	X	
Pterophoridae (Plume moths)		
Leioptilus		
beneficus		X
Stenoptilodes		
littoralis rhynchophora	X	
Sphingidae (Hawkmoths)		
****Agrius***		
cingulata	X	X
****Macroglossum***		
pyrrhostictum		X
****Theretra***		
nessus		X
Tortricidae (Leaf roller, leaf tiers)		
Amorbia		
emigratella		X
Bactra		
straminea	X	X
Cryptophlebia		
illepida		X
Tineidae (Clothes moths)		
Opogona		
omoscopa	X	X

* Collected at the proposed correctional facility survey site in 1999 by Bishop Museum staff (Howarth et al., 1999).

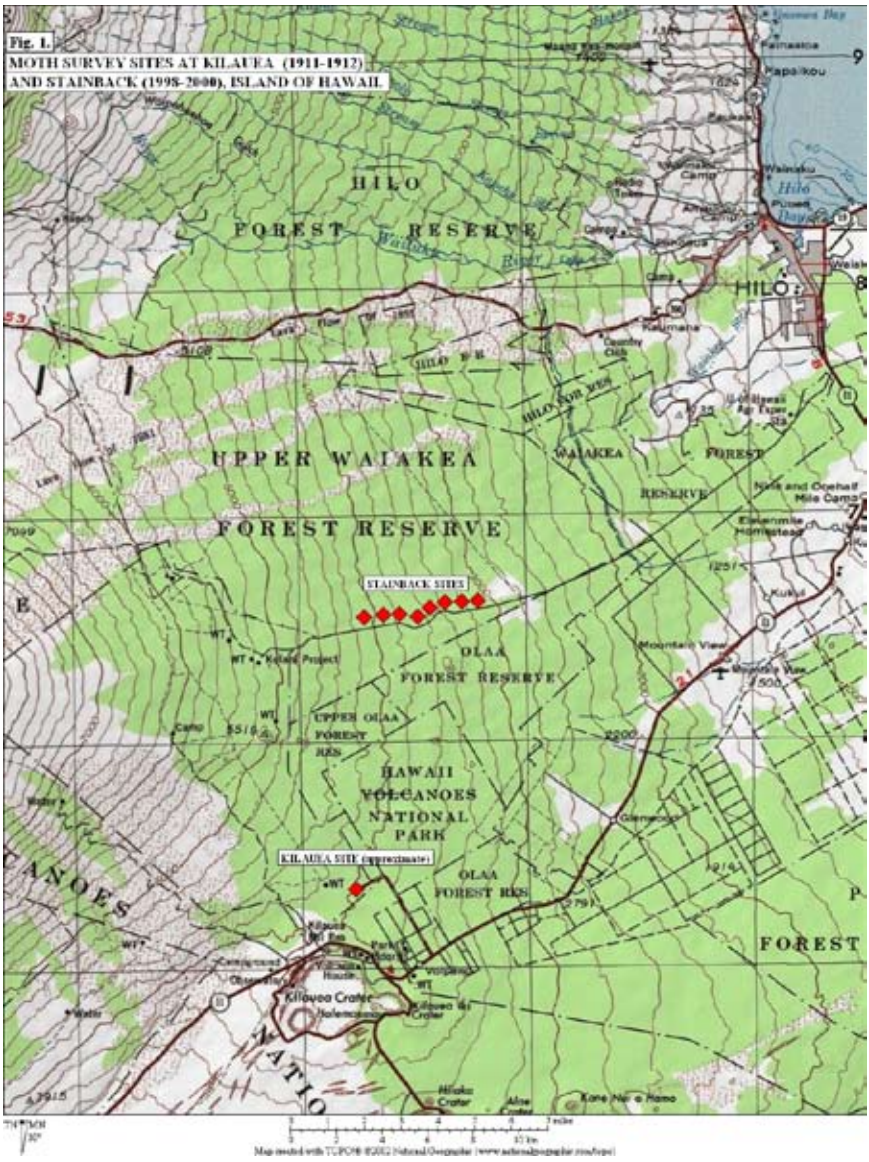

Fig. 1. MOTH SURVEY SITES AT KILAUEA (1911-1912) AND STAINBACK (1998-2000), ISLAND OF HAWAII.